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SOIL CONSERVATION SERVICE

EROSION WITH STRIP CROPPING AND TERRACING IN THE TEXAS BLACKLANDS

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in cooperation with

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EROSION WITH STRIP CROPPING AND TERRACING IN THE TEXAS BLACKLANDS

H. O. Hill*

In contrast to the success of terracing, strip cropping, and contour farming in reducing soil and water losses in most farming areas of the United States, the application of these measures has met with difficulties and some failures in the Blackland Prairie of Texas. Here, as elsewhere, however, it has been demonstrated that a permanent cover of vegetation such as grass will reduce erosion to the point that soil formation can keep up with the erosion process.

The purpose of this paper is to describe the erosion conditions that have followed the use of strip cropping with certain crop rotations on the Blackland Prairie soils of Texas.

The occurrence of interterrace erosion is also discussed under the following conditions: (1) Where terrace intervals were planted entirely to row crops; and (2) where the intervals were (a) entirely in row crops, and (b) planted to a rotation of row crops and oats.

The limitations of some of these conservation practices as applied to the Blackland Prairie of Texas will be pointed out.

Field Layout and Procedure

There are two types of erosion control measures, vegetative and mechanical. Strip cropping and terracing are examples of these types.

Most of the Blackland Prairie of Texas is cropped to cotton, corn, and small grains. The principal small grain grown is oats. Among the general crops grown here, small grain, sorghum, sudan grass, and legumes possess some erosion-resistant features. Oats and broadcast sumac sorgo, commonly called cane, were used as the erosion-resistant crops in this study. One question in this connection was: Which is the most effective, oats or cane? A setup, designed to give information on this problem, was made in a field with uniform soil and slope. This field was divided into two equal parts. Crop strips, 36 feet wide, were laid out so that one-third of the land was in cotton, one-third in corn, and one-third in the erosion-resistant crop. In the northern part of the field the resistant crop was cane; whereas, in the southern part the resistant strip crop was oats.

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Another question for consideration was: If strip cropping is effective in reducing erosion on gentle slopes, how steep is the slope on which it will remain effective? In order to get information relative to this question three fields were selected with three different degrees of slope, about 2-, 3-, and 3-1/2-percent each. On a fourth field with a 4-1/2-percent slope the resistant strip of oats was aided by the addition of a permanent buffer strip. The upper side of this buffer strip of bluestem meadow was on the contour. In all the other fields above referred to, there was a contour line laid off for each of three crop strips. The crops were rotated about the contour line in such a manner that at least one side of the row-cropped area or the center was on the contour line and parallel to it. The width of row-crop strips planted to cotton and corn was always uniform in each field so that there were no point rows. All the irregular space that would normally have been in point rows was taken up by the resistant-crop strips.

In addition to these field layouts of strip cropping, twelve 1-1/2-acre plots were laid out on two different slopes, six on a slope of about 2-percent and six on a slope of about 3-percent. Soil-loss measuring devices containing eroded soil are shown in figure 1.

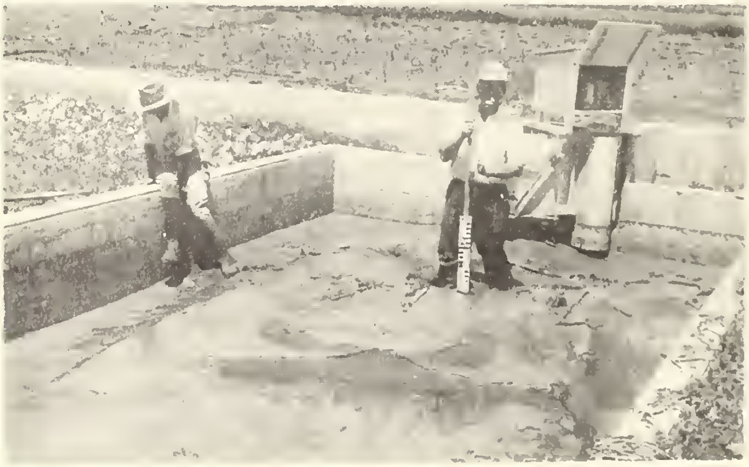

Figure 1. Eroded soil in measuring device of 1 1/2-acre strip-cropped plot 05.

The difficulty of measuring erosion in the large strip-cropped fields is apparent. In place of measuring the soil and water loss two types of field techniques were perfected and used. After each storm a tape and sketch survey was made to locate and record the number and extent of gullies that formed as a result of the particular rainstorm. In addition to the location of these gullies, an attempt was made to arrive at the volume of soil that had been removed by flowing water. At intervals down the gullies, cross-sectional measurements were made and the size of the cut recorded; for example the gully might be recorded as 3 inches deep by 4 feet wide.

Previous investigations have shown that a precise soil-movement profile line up-and-down the slopes would not show the extent of soil that had been eroded (2)[1]. It was found that the surface of the ground varied as much as 1-1/2 inches in elevation during one season. This difference in elevation was due to the swelling and shrinking of the soil profile as the moisture content increased and decreased (2, 3). Such a large seasonal variation could easily offset, by many times, the one-sixth of an inch of soil loss annually that is known to occur from row crops on a 4-percent slope of this area. However, the magnitude of soil washed from a depression developing into a gully is such that it would readily show up on a soil-movement profile line if the measurements were taken across the slope. Starting in 1938, the cross-slope profile lines were run every 2 years on fields under this study where soil loss was not measured. Elevations along the line were taken every 2 feet. The horizontal distance was located by means of a steel tape stretched along a straight line between two bench marks.

Soil and Rainfall

The soils at the Blackland Experiment Station at Temple, Texas, where the experiments were conducted, are Houston Black clay and Austin clay, typical of most of the Blackland prairie. These soils are normally crumbly and work easily when moisture conditions are favorable. When the weather becomes dry the soil gets very hard and upon plowing breaks up into large clods (3). As moisture becomes available these clods slowly break down and form a very satisfactory seedbed with a minimum of cultural operations. When the soil becomes wet it swells not only at the surface but below the surface and also seals over so that both percolation and infiltration practically stop. After this sealing action takes place most of the rainfall is lost as runoff. If the rainfall is intense, this runoff will be heavily laden with soil. The beating action of the rainfall detaches the soil particles so that they can be easily transported by the large quantity of runoff water (1,6).

The normal annual rainfall at the Blackland Experiment Station is about 36 inches. The greater part of this rainfall comes in intense storms during the spring and early fall. The rain of May 18 and 19, 1942, is a typical rainstorm of the area. The total rainfall of this storm was 3.36 inches. This rain fell at the rate of 3.6 inches per hour for a 5-minute period, 2.4 inches per hour for a 15-minute period, and 2.34 inches per hour for a 30-minute period. A rain of this kind can be expected at least once every year and it frequently occurs in May. At this time corn is about knee high, cotton about 4 inches high, oats are about ready to harvest, and sorghum is about 6 inches high.

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[1] Parenthetical numbers refer to literature cited.

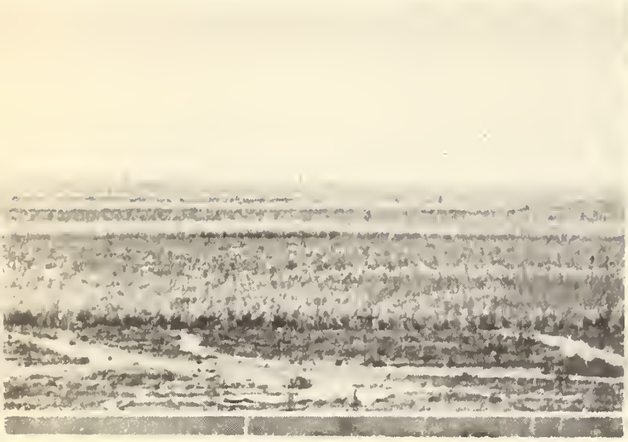


Figure 2. **A** portion of plot 05 taken during the storm of May 18 and 19. The gullies pictured here can be observed on the map of figure 3.

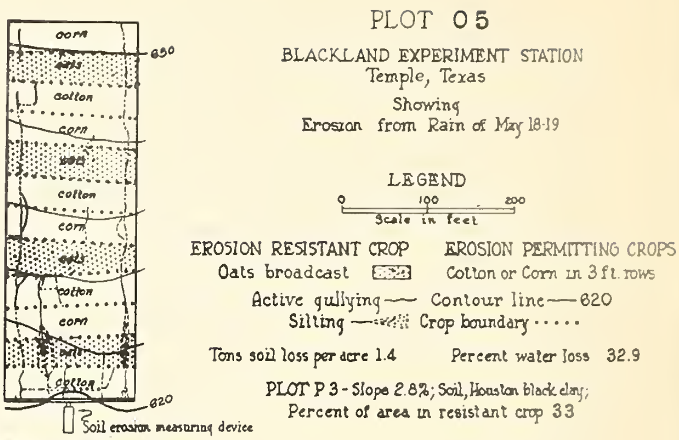


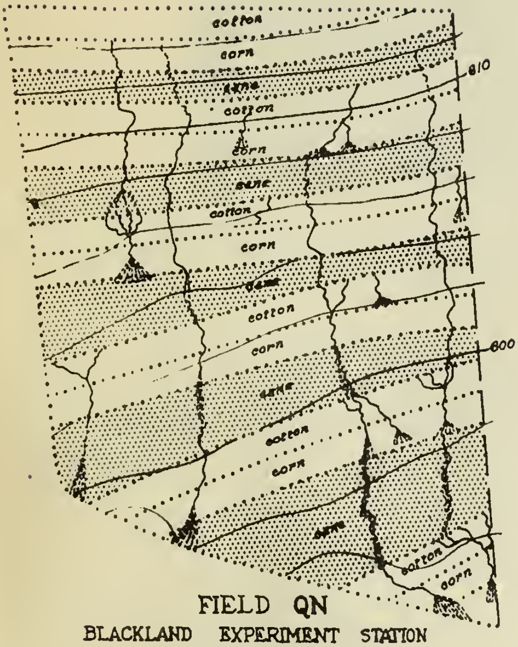
Figure 3.

Measurement of Soil Loss as Compared to Field Sketches of Gullying After Storms

Several characteristics of field gullying were compared with the gullying which occurred on the same soil in the plots under measurement. It was found that the number of gullies increased as the soil loss increased. A sketch of the respective fields and plots after a rainstorm reflected the severity of the erosion by the number of gullies formed. No other characteristic, except the number of gullies forming, gave any correlation with the amount of soil loss. Factors considered were: Total length of area disturbed by flowing water; total length of active cutting in gullies; total volume of soil cut away by gullies; and the number of gullies formed. Figure 2 shows a number of gullies in plot 05. The field map of plot 05 is shown in figure 3.

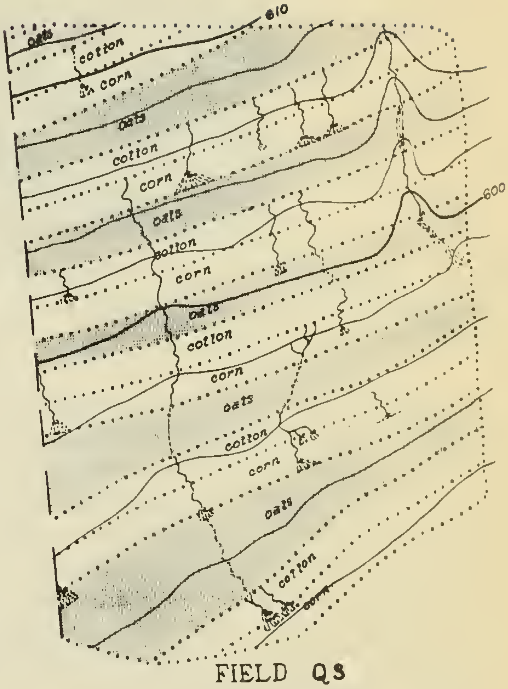
A Resistant Strip of Oats Compared to One of Broadcast Cane

The ideal resistant strip in a strip-cropping system would be one that occupied the land the year around. Since it is not always possible to have this kind of a permanent strip, certain annual cultivated crops may be used. On field QN, figure 4, the resistant strip was broadcast cane. On field QS, figure 5, the resistant strip was oats. At the time of the rainstorm in this study, May 18, 1942, the oats were headed and the sorghum was about 6 inches high. Of course the big difference between these two crops is that oats are fall planted and provide good winter and spring protection against erosion, whereas, sorghum is spring planted and does not generally make much cover before June. Field QN and QS were similar except for the resistant crop strips. It will be observed that there were three major gullies that went almost from the top to the bottom of QN, across all the strips. Figure 6 shows the south gully of this field as photographed during the storm of May 18.



FIELD QN
BLACKLAND EXPERIMENT STATION
Temple, Texas
Showing
Erosion from Rain of May 18-19
LEGEND
0 100 200
Scale in feet
EROSION RESISTANT CROP EROSION PERMITTING CROPS
Cane broadcast ▨ Cotton or Corn in 3 ft rows
Active gullying —— Contour line —— 600
Silting Crop boundary .... Field division — —
FIELD QN – Slope 2.8%; Soil, Houston black clay;
Percent of area in erosion resistant crop 44

Figure 4.



FIELD QS
BLACKLAND EXPERIMENT STATION
Temple, Texas
Showing
Erosion from Rain of May 18-19
LEGEND
0 100 200
Scale in feet
EROSION RESISTANT CROP EROSION PERMITTING CROPS
Oats broadcast ▭ Cotton or Corn in 3 ft rows
Active gullying —— Contour line —— 600
Silting Crop boundary .... Field division — —
FIELD QS – Slope 2.9%; Soil, Houston black clay,
Percent of area in erosion resistant crop 44

Figure 5.

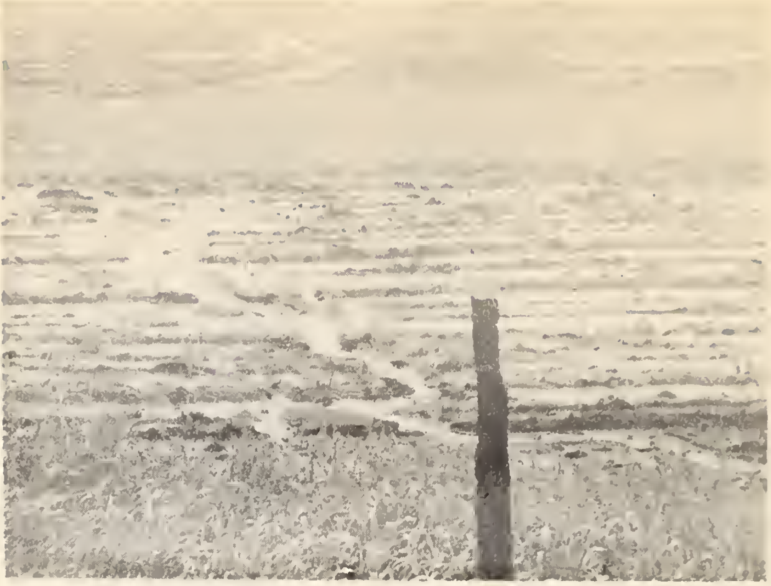


Figure 6. The south gully of field QN. This gully extends from the top to the bottom of the field across all the crop strips including those of broadcast cane. This picture was taken during the storm of May 18.

In QS it will be noted from the maps that there was only one gully that extended anywhere near the entire length of the slope across the oat strips. Also, in QS there were a number of embryo gullies that began in the cotton strips and which became obliterated upon running into the first strip of oats. This illustrates one of the purposes of resistant strips, that of filtering out the soil in silt-laden runoff. Another purpose of the resistant strip is to increase absorption of water so there will be less to continue down slope. If the resistant strip accomplishes this last purpose, the gullies will not start to cut immediately below the resistant strip. An erosion-resistant strip is not fully effective if water flows from it and begins to develop another gully in the row-crop area immediately below the resistant strip.

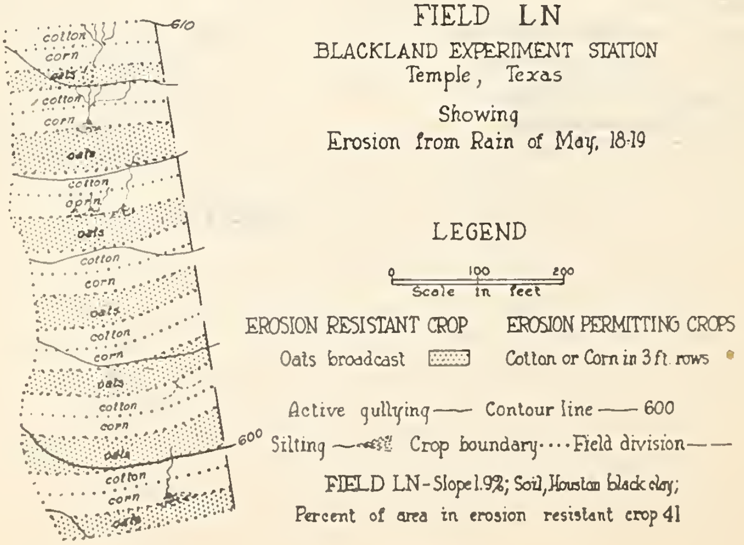


Figure 7.

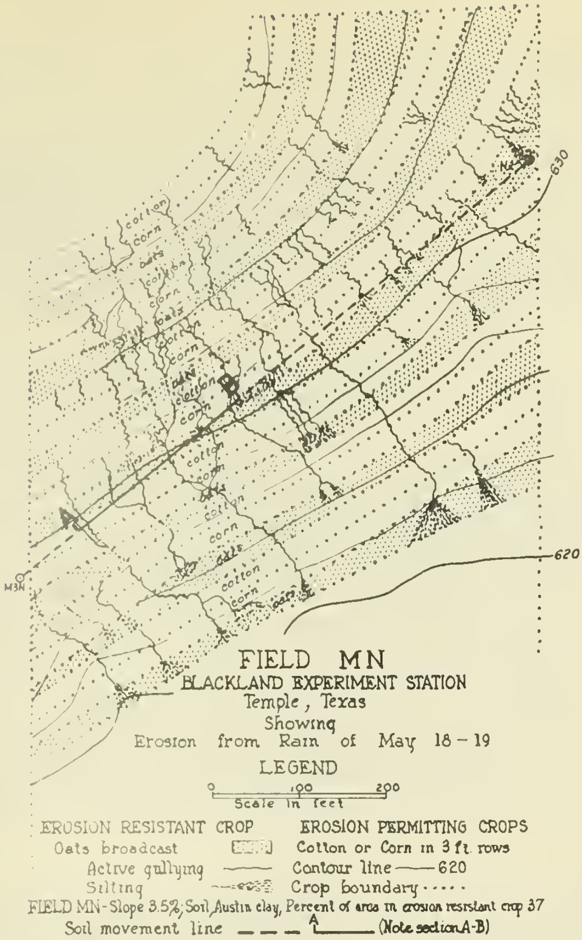


Figure 8.

Erosion on Different Degrees of Slopes

It is well known that the steepness of the slope has a very marked effect on soil erosion. The effect of degree of slope was considered on field LN, field QS, and field MN. These fields have slopes of 1.9, 2.9, 3.5 percent respectively. The length of slope over which water may flow in each of the fields is about the same; between 500 and 600 feet. About 40 percent of these fields was occupied by the erosion-resistant strips of oats. Another slight difference between the fields was that the crop widths in fields LN and MN were 24 feet and those in field QS were 36 feet. It requires only a brief glance at these three maps (figs. 5, 7, and 8) to see that the general statement concerning increase of erosion with increase of slope is also true with gully erosion on strip-cropped fields. It is evident that field MN was eroded considerably more than QS and in turn QS was more severely eroded than LN. It is of particular interest to note on field LN that in most cases the gullies had their beginning and end within the row-crop area without ever reaching the resistant strip. Much of the effectiveness of strip cropping is due to the fact that the row crops are contoured. It can be said that strip cropping with narrow strips is little better than contour farming. Also, if the slope is steep enough or gullied enough that contoured rows will be broken, then strip cropping on such a field is doomed to failure. From the three maps shown above it would seem that strip cropping will not be successful on Blackland slopes greater than 2 percent.

Permanent Meadow Grass Buffer Strips

The fact that steeper slopes erode more severely than flatter ones is recognized. As a result more intensive erosion-control measures are needed on steep slopes. Field LS, figure 9, has an average slope of 4.8 percent. The slope length is about 700 feet, with permanent meadow buffer strips of little bluestem. These were placed 162 feet apart, and arranged so that the point rows were taken up by the meadow strips. The upper side of the meadow strips were on the contour, and the cultivated area between them was divided into three strips with equal widths of 54 feet each. On these three strips a 3-year rotation of cotton, oats, corn was practiced. In May 1942 the oats were immediately below the bluestem. This gave a very broad band of resistant strips on this field. In fact, 55 percent of the field was devoted to resistant strips of oats and meadow combined.

A look at the map of field LS will show that frequent gullies were formed from the rain of May 18 and 19 on this slope of 4.8 percent. It will also be seen that these gullies for the most part extended completely across the row crops in the field. The desilting effect of the meadow strips was shown by the silt delta formations immediately above the bluestem strips. However, this is not the whole story; it will also be observed that the gully erosion started immediately below the resistant strips.

As more strip-crop fields are observed, it becomes increasingly evident that the runoff water is not being absorbed in the resistant strips. This fact points out the need of terraces to remove this excess runoff water that starts eroding the row-crop land just below the resistant strips.

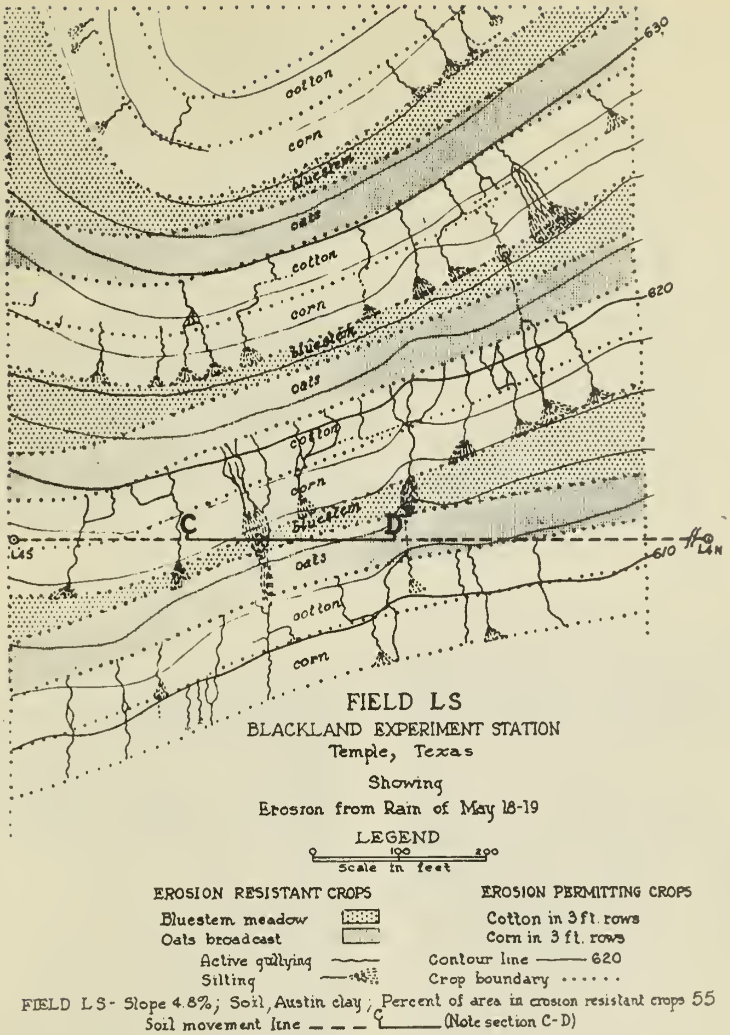


Figure 9.

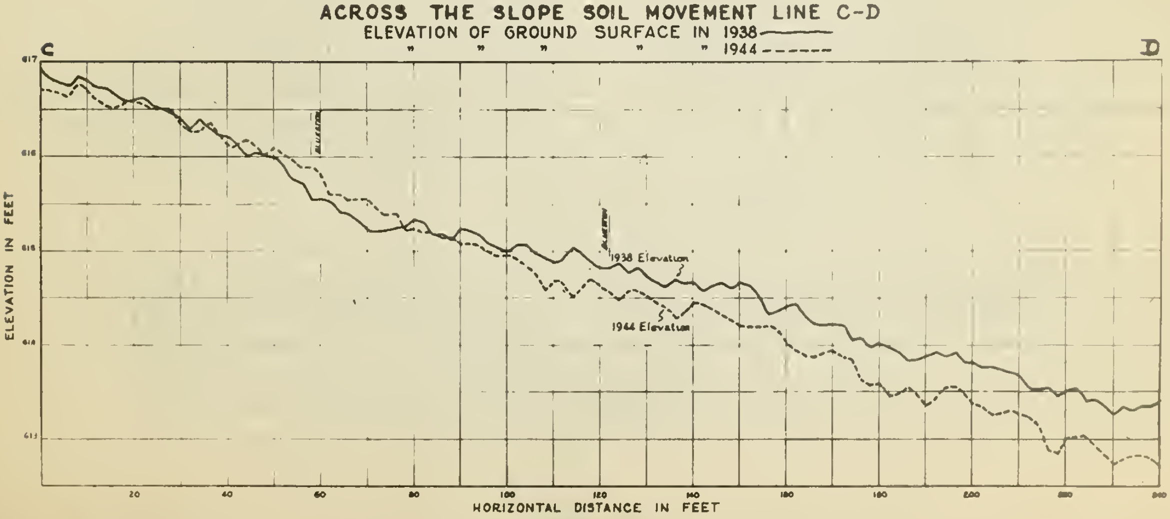


Figure 10.

The cross-slope-soil-movement line, of which section CD, figure 10, is a part, tells a story of destruction. It is hard to believe that in the short period of 6 years from 3 to 6 inches of good topsoil has been eroded from the row-crop strip immediately below the meadow buffer strip. It is also hard to believe that the meadow grass has allowed soil to be eroded from around its roots. In 6 years, from 1938 to 1944, the upper part of the meadow buffer strip had built up about 3 inches. (fig. 11). This deposit of soil was laid down because the grass slowed the velocity of the runoff water and caused it to drop its load. Since the soil was mostly sealed over and could absorb very little more water, the runoff water had no place to go except to continue down the slope. This it did, slowly trickling through the grass strip, gaining velocity as it entered the plowed area below. As its velocity increased it was able to begin cutting and eroding soil again. The effect of plowing the cultivated land immediately below the meadow also contributed to down-slope movement of soil in this area. The combined effect of erosion plus the plowing effect caused a jump-off of about 4 inches from the level of the meadow to the level of the cultivated land (fig. 12).

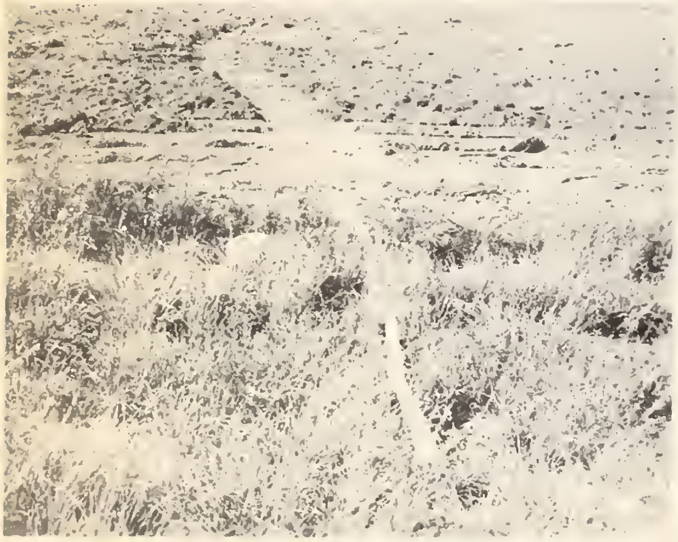


Figure 11. This soil deposit at the upper side of a bluestem meadow Buffer strip shows the desilting effect of a permanent grass cover.

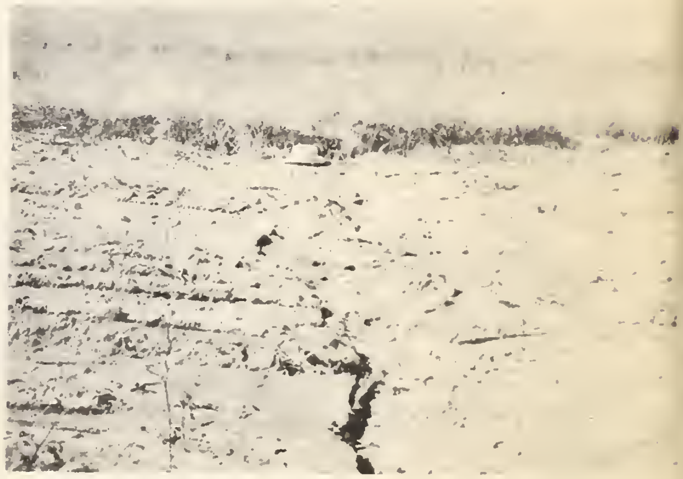


Figure 12. Plowing loosened the soil and unabsorbed water from a meadow Buffer strip helped to move this soil more rapidly down the slope leaving this "jump off" effect.

The Birth of a Gully

The cross-slope-profile-soil-movement line of which section AB, figure 13, forms a part is in field MN (fig. 8). From 1938 through 1946 this field was planted in 24-foot widths to cotton, oats, and corn in a 3-year rotation. The frequent gullies indicate that strip cropping has been far from satisfactory. An examination of section AB of the soil-movement line verifies this fact. The difference in the surface elevation between 1938 and 1944 shows that what were depressions in 1938 had become definite gullies by 1944.

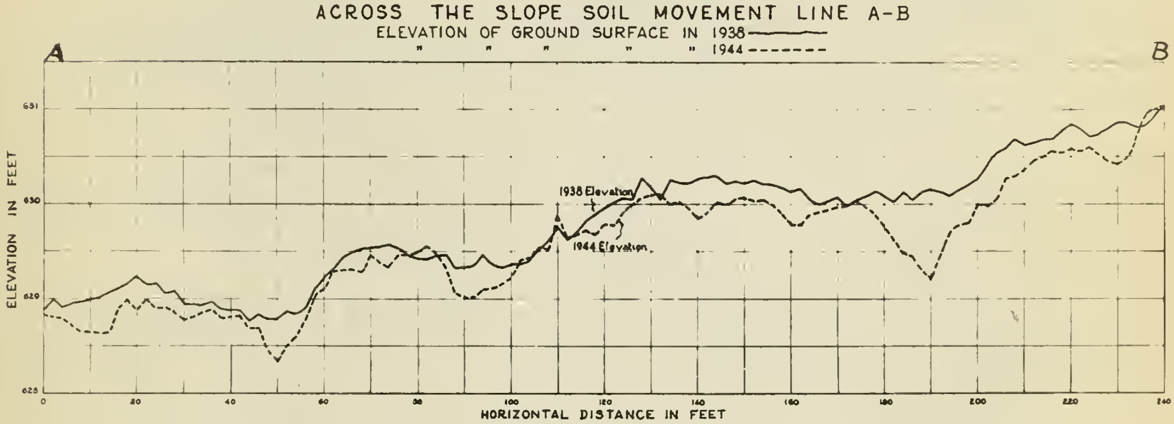


Figure 13.

Erosion on Horizontally Concave and Convex Slopes

It was observed that there is more severe gully erosion on concave slopes than on convex slopes. This phenomenon was observed in field MS (fig. 14 and field MN (fig. 8) which is adjacent to field MS, with only a turn row between. A common statement as to the reasons for more gullying on a concave slope would be that the concave slope tends to "push the water together." It is also evident that the drainage-dividing line of the convex slope is actually the boundary between two watersheds, whereas the center of the concave slope is actually the waterway that drains the watershed.

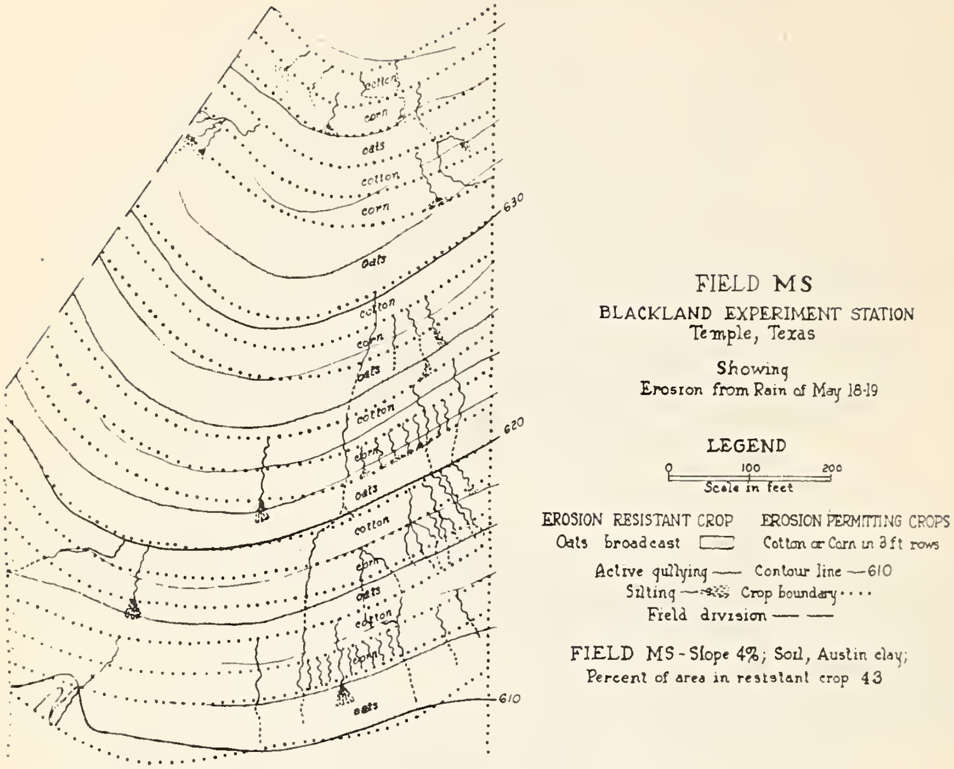


Figure 14.

There is another way to visualize this convergence of water on the concave slope. If a number of lines are drawn perpendicular to the upper contours of the slope, it will be noticed that the lines on the convex slope never cross, whereas those on the concave slope cross and recross many times. If the lines thus drawn are considered as raindrops or streamlets of running water it can easily be seen why the increased amount of water flowing over the concave slope will increase gullying on the slope.

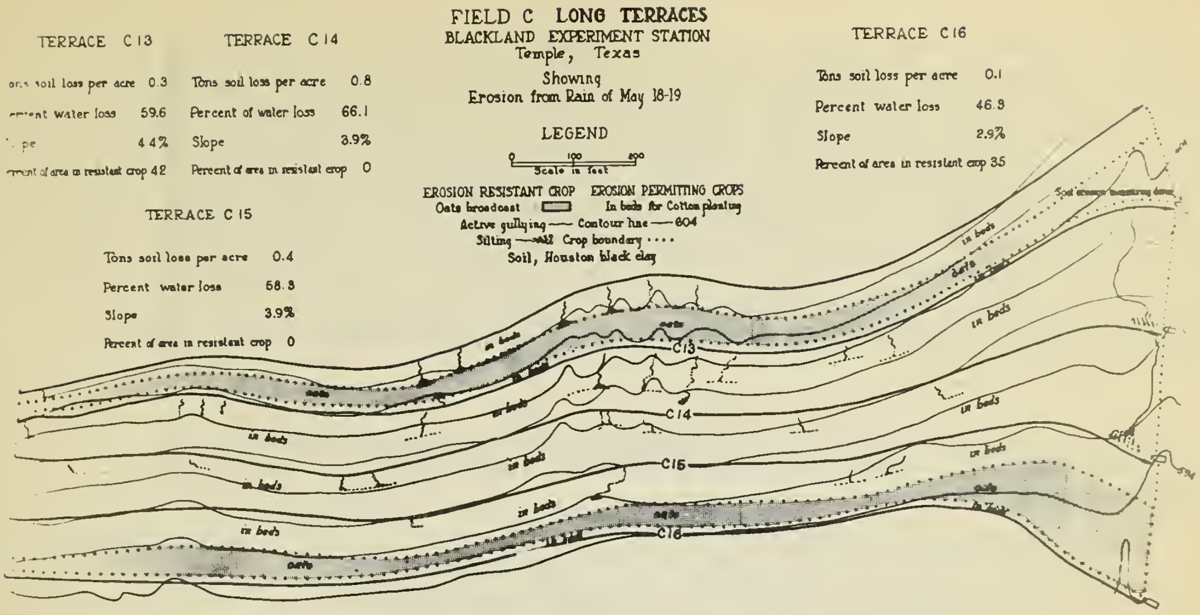


Figure 15.

Interterrace Erosion

The terraced field shown in figure 15 contains terraces about 2,000 feet long. The center two of these were cropped entirely to row crops and the two outside ones were cropped partly to row crops and partly to oats as a resistant strip immediately above the terrace channel. At the time of the May 18 and 19 rain the row-crop land was bedded in preparation for planting row crops. At this time the oats were well headed and about ready to cut. The average slope of this terraced land is 3.8 percent. It will be observed that there was some interterrace erosion. Generally the small gullies started and broke the beds about one-half the width of the terrace interval and then were obliterated as the flatter part of terrace interval was reached. On the terraces where the strip crops were used above the terrace channels, the gullies were stopped by a filtering action at the upper edge of the oats strip. Where the entire interval was in beds the gullies were obliterated by a lateral movement of the soil and water along the bedded rows.

Interterrace erosion has long been recognized. However, it has been established by soil-loss measurements from terraces, that terracing reduces the soil eroded from the fields to about one-tenth of that experienced on a similar field without terraces. What the terrace actually does, then, is to "fence the soil in" and dispose of the runoff water in such manner that the minimum of gully damage is done to the land. It is quite evident from figure 15 that gullying which would normally extend down the length of the slope has been stopped by terracing.

What then is the extent of interterrace erosion? How might this erosion between the terraces be further reduced? Also, what can be done about that soil which is deposited in the terrace channel? Soil losses from the erosion plots on this station give an idea about the interterrace erosion that would occur on terraced land cropped to the respective crops or rotations. Furthermore, those crops and cropping practices that would reduce the amount of soil loss from these erosion plots would also reduce the amount of interterrace erosion (5). The rate of soil erosion from different crops on these control plots determined from 1946 to 1947 and the results are shown in table 1.

The soil loss from corn and Bermuda grass has been measured for 17 years with an average loss that closely corresponds to that of the 2-year period.

Table 1.--Rate of soil erosion from different crops on the control plots from 1946 through 1947

Crop	Time required to erode 1 inch of soil
	Years
Corn after corn	7
Cotton-corn rotation	6
Cotton-oats rotation	9
Cotton-oats (h) rotation	13
Cotton-hubam rotation	18
Cotton of a cotton-oats rotation	5
Cotton of a cotton-oats(h)rotation	7
Cotton of a cotton-hubam rotation	10
Oats of a cotton-oats rotation	158
Oats (h) of a cotton-oats (h) rotation	218
Hubam of a cotton-hubam rotation	226
Bermuda grass continuous	6000

These erosion plots are 72.5 x 6 feet on a 3.8-percent slope of Austin Clay. The row crops on these erosion plots were planted almost flat in an uphill and downhill direction. Had the rows been contoured the length of soil life would have been doubled (2).

Soil-movement lines at this station have shown that the normal method of terrace cultivation plows more soil from the terrace interval into the terrace channel than is ever washed into the channel by erosion. When breaking plows turn the soil downhill from the center of the terrace interval the effect is to move the terrace ridge up the slope and to form a very broad flat channel (2). Also, the practice of flat breaking the terrace interval as a single plowland moves so much soil with the plow that the subsoil is exposed in the center of the terrace interval on shallow soils. Thus it is seen that terracing and resistant crops are not all there is to keeping the soil in place. Attention must be given to the cultural operations that move soil, namely, plowing. At the Tyler, Texas, Conservation Experiment Station it was found that the use of the hillside plow for working terrace land overcame the deficiencies of normal plowing procedures (4). With the use of the hillside plow all the furrow slices can be turned uphill. This type of plow has two bottoms, one that turns the soil to the right and one that turns it to the left. By a mechanical device to switch the position of the bottoms at each end of the field, the plow can be made to turn the soil uphill.

Summary and Conclusions

This paper presents a study of erosion that occurs after certain recognized soil conservation practices have been applied. Strip cropping and terracing are the principal practices considered. The field layout and technique for recording gullying are described. The rain of May 18 and 19, 1942, was selected as a typical rainstorm of the Blackland Prairie of Texas. Figures are presented that record the location of gullies that occurred as a result of this rain. Interterrace erosion is discussed and measured soil loss is presented for different crop covers. Cross-slope profiles are presented showing the result of recurring gully erosion over a period of years. Considering the erosion conditions found, the following conclusions were reached.

1. On the Blackland soils gullies must be prevented from progressing down the full length of the slope. On soils with low infiltration rates, this requires the use of terracing if the slope is greater than 2 percent.

2. Terracing "fences the soil in." An increased use of erosion-resistant crops in rotations is needed to keep the soil in place within the terraced field. Hubam sweetclover or similar legumes are good for this.

3. Down-slope movement of soil is certain to occur where sloping soils are cultivated. If cropping with normal tillage does not keep the soil in place it may be necessary to resort to uphill plowing with a two-way plow. This practice counteracts interterrace erosion to a large extent by keeping the annual soil deposit in the terrace channel plowed back uphill.

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